

# Tele-Echocardiography: Utilization for the Diagnosis and Management of Children With Congenital Heart Disease

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## INTRODUCTION

In Iowa, the geographic distribution of the population makes telemedicine connections an efficient way to deliver tertiary care services to underserved areas. We established "connections" around the State of Iowa using (1) a courier service, (2) Integrated Services Digital Network-Primary Rate Interface (ISDN-PRI) connections operating at 1.54 Mbps, and (3) DS3 links operating at 45 Mbps. The goals of the current study were to examine the utilization and diagnostic yield of remote pediatric echocardiographic services, the effectiveness of the various transmission methods, and the diagnostic accuracy of the tele-echocardiographic service.

## METHODS

### Study Group

Echocardiograms were sent from various locations around the State of Iowa. Transmission distances ranged from 25 to 290 miles. At each location, at least one adult sonographer was trained to perform pediatric echocardiograms. For some of the analyses presented below, locally ordered echocardiograms were compared with those ordered by pediatric cardiologists at outreach clinics in the same community. Outcome analyses were performed using all the echocardiograms transmitted to the Pediatric Echocardiography Laboratory (PEL) between March 1995 and March 2000. This data set included 1,138 pediatric echocardiograms.

### Transmission Methods

Echocardiograms were sent to the PEL by a variety of methods. Depending on the site and its distance to the PEL, echocardiograms were sent via a DS3 connection or an ISDN-PRI link, or by courier. Analyses were performed to compare the time intervals involved in receiving and providing results using the various transmission schemes. In addition, physicians transmitting echocardiograms by courier from a nearby site (25 miles) and via a DS3 connection were surveyed to determine their satisfaction and perceived limitations of the service.

### Echocardiogram Interpretation

The pediatric cardiologist attending the inpatient service generally interpreted transmitted electrocardiograms. Echocardiograms were stratified into normal or abnormal groups on the basis of these interpretations.

### Statistics

All data are presented as mean  $\pm$  standard error of the mean. Time interval data among the three modes of transmission were compared using analysis of variance (ANOVA) with pairwise comparisons made using Tukey's F-test. Average

response values from the survey data were compared among groups using Wilcoxon's rank sum test. Contingency table analyses were performed to calculate chi-squared values on some data. For all comparisons,  $P < 0.05$  was considered significant.

## RESULTS

### Local Physician Satisfaction

Some of the results summarized here have been more extensively presented elsewhere<sup>1</sup>. Quality assessment of the pediatric tele-echocardiography service was performed by surveying 35 local physicians, who together ordered 62 percent of the echocardiograms that were transmitted to and interpreted by the PEL. Local physicians tended to be satisfied with the service and said they would enthusiastically recommend it to their colleagues. Comparisons among studies transmitted by the DS3 connection and those sent by courier found that physicians using the courier service were significantly more concerned about the availability of a pediatric cardiologist and image quality.

### Interpretation Times

Time intervals between performing a study locally and returning the results to the local physician were compared for two ISDN-PRI sites, two DS3 sites, and two courier delivery sites (one 170 miles away and one 25 miles away). As expected, the interval between the time the echocardiograms were recorded locally and the time the study was received in the PEL was significantly increased for studies delivered by courier from the site 170 miles away ( $2,474 \pm 295$  minutes) compared with either the courier from the site 25 miles away ( $474 \pm 151$  minutes), DS3 ( $374 \pm 121$  minutes), or ISDN-PRI ( $129 \pm$

16 minutes). Other time intervals up to report generation were no different among the three groups. Therefore, the critical time interval between recording a study and reporting its result to the referring physician was primarily determined by the transmission time interval.

### Utilization of the Tele-Echocardiogram Service

In general, the community physicians ordered echocardiograms to further evaluate a heart murmur, although other reasons for ordering an echocardiogram included tachycardia, chest pain, syncope, and positive family history of congenital heart disease. Approximately 75 percent of the 1,137 echocardiograms performed locally were in infants younger than 1 year of age. Figure 1 shows that in this age group, the percentages of normal and abnormal transmitted studies were no different between echocardiograms ordered by local physicians and those ordered by pediatric cardiologists in

outreach clinics in the same communities. However, in children older than 1 year of age, a significantly greater percentage of echocardiograms ordered by local physicians were normal.

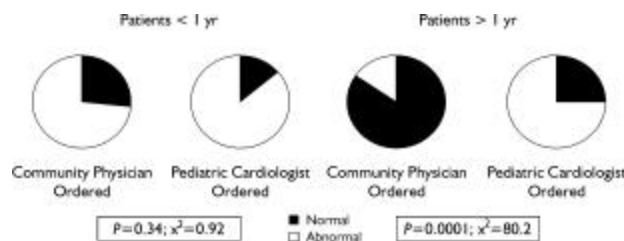


Figure 1. Percentage of Normal and Abnormal Transmitted Studies: Local Physicians and Outreach Clinics

## Echocardiogram Accuracy and Followup

Between March 1995 and March 2000, 1,137 echocardiograms were sent to the PEL for interpretation. Of these, 651 (57 percent) were read as abnormal. During a median followup period of 687 days, 104 of the children with abnormal echocardiograms were seen for reevaluation. Followup was at the University of Iowa (48 percent) or university-sponsored pediatric cardiology outreach clinics (31 percent) or by repeat echocardiogram by the local physician (21 percent). Of these 104 children seen in followup, the initial diagnosis was changed in 6 (6 percent). In each case, normal development (the postnatal drop in pulmonary vascular resistance) or the natural history of the disease (closure of a ventricular or atrial septal defect or progressive valve disease) could explain the change in diagnosis. Children initially diagnosed with normal hearts by the transmitted echocardiogram were also seen in followup. In some cases, it was to receive additional information from a pediatric cardiologist. In two patients, an abnormal diagnosis was subsequently made (both had coarctation of the aorta). Since each patient for whom an echocardiogram was transmitted was not seen in followup, specific calculation of diagnostic accuracy of the remotely performed echocardiograms was not possible.

## DISCUSSION AND CONCLUSIONS

Transmission of pediatric echocardiograms from remote adult echocardiographic laboratories is an effective method to extend the reach of pediatric cardiology subspecialty services. Our data indicate that local physicians prefer real-time connections that allow more rapid feedback from the pediatric cardiologist interpreting the echocardiogram. Dedicated or dial-up transmission methods resulted in shorter turnaround times between performing a study and receiving the results.

Accurate diagnosis of the specific congenital heart lesion was critical. Though difficult to quantitate, careful sonographer instruction was important for obtaining diagnostically accurate images. The methods of transmission used in the current investigation were all of equal quality; thus, significant

limitations in diagnostic accuracy were not detected. Local physicians did tend to overutilize the service, particularly in children older than 1 year of age. The cost-effectiveness of the echocardiographic interpretation service in these older children has been considered<sup>2</sup> and found to be fairly efficient. However, clinic and procedure costs significantly influence these calculations, which may make a tele-echocardiographic service less cost-efficient.

Clearly, infants and children with suspected congenital heart disease are better served when accurate diagnostic information can be obtained locally and interpreted in a timely fashion. Tele-echocardiography can accomplish this result with a combined program of sonographer training, telecommunication engineer ingenuity, and pediatric cardiologist expertise.

## ACKNOWLEDGMENT

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## REFERENCES

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